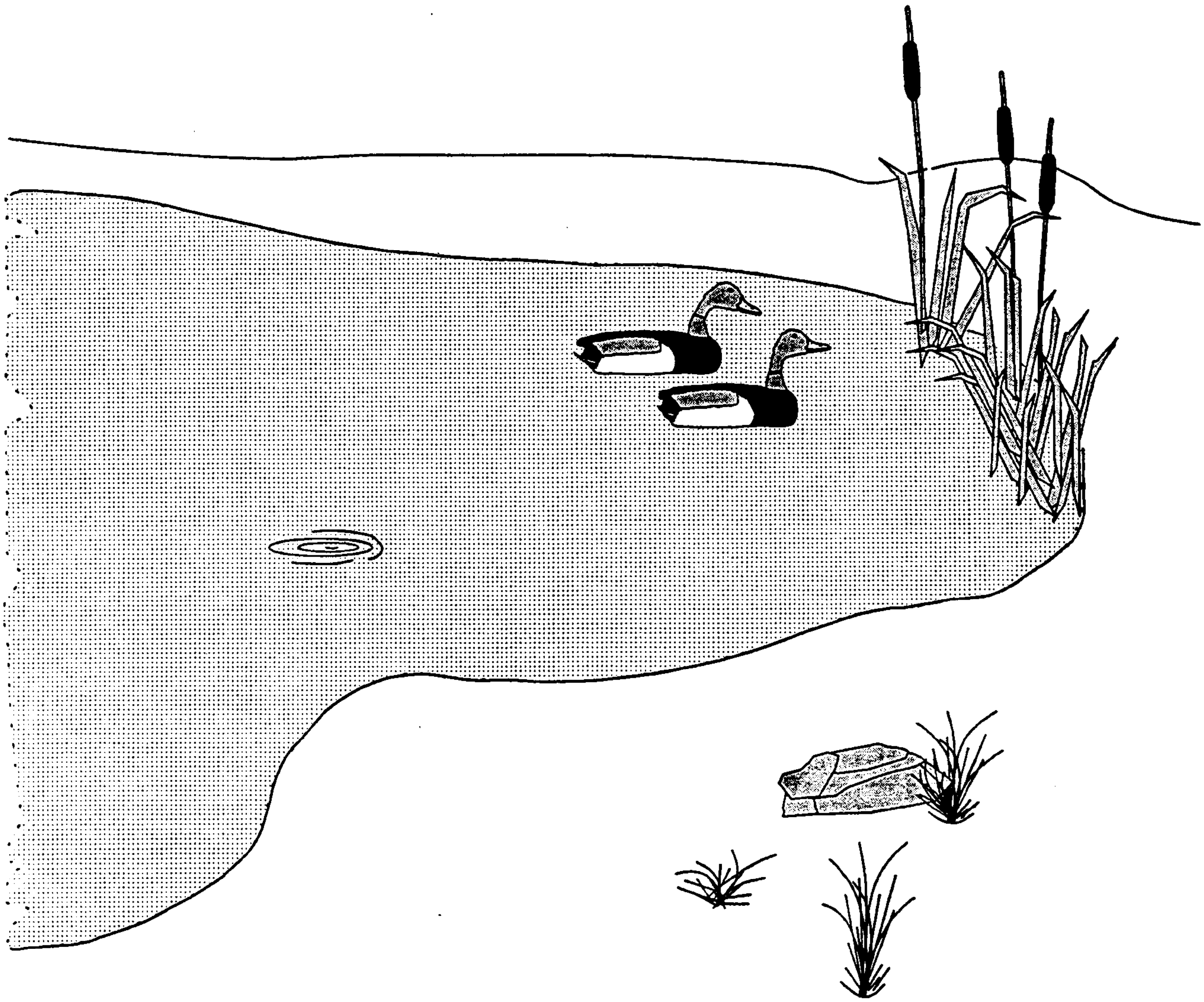
U.S. FISH AND WILDLIFE SERVICE
Region 2
ENVIRONMENTAL CONTAMINANTS PROGRAM

A 1991 FOLLOW-UP INVESTIGATION OF SELENIUM, MERCURY AND LEAD CONCENTRATIONS IN SEDIMENT AND BIOTA FROM LAS VEGAS NATIONAL WILDLIFE REFUGE, SAN MIGUEL COUNTY, NEW MEXICO



U.S. Department of the Interior
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A 1991 Follow-Up Investigation of Selenium, Mercury, and Lead Concentrations in Sediment and Biota from Las Vegas National Wildlife Refuge, San Miguel County, New Mexico

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U.S. Department of the Interior
Fish and Wildlife Service
New Mexico Ecological Services State Office

Appendix D.-Continued. Contaminant concentrations detected in sediment **and** biota samples collected at Maxwell National Wildlife Refuge, June-September, 1991.

Trace-elements (ug/g, dry weight)

Sample (Sample Number) ▼	Percent Moisture	sample Weight (g)	Selenium	Mercury	Lead
Sediments (46)	66.2	348.0	< 0.2947	< 0.0982	16.1
Sediments (47)	33.4	412.7	< 0.2982	< 0.0994	1.82
Sediments (48)	37.6	279.4	0.68	< 0.0996	25.5
Sediments (49)	55.9	390.3	< 0.2982	< 0.0994	17.
Sediments (SO)	63.9	442.3	< 0.2959	< 0.0986	16.7
Sediments (99)	46.5	304.8	0.54	**<0.1**	13.9
Sediments (100)	30.3	375.	0.39	< 0.0996	11.3
Sediments (101)	34.	340.	0.38	**<0.1**	14.4
Sediments (102)	31.3	354.4	< 0.2988	< 0.0996	13.6
Sediments (103)	25.1	375.6	< 0.2982	< 0.0994	10.
Sediments (104)	32.9	283.5	0.33	< 0.0988	15.6

Appendix D.--Continued. Contaminant concentrations detected in sediment and biota samples collected at Maxwell National Wildlife Refuge, June-September, 199 1.

Trace-elements (ug/g, dry weight)

Sample (Sample Number)▼	Percent Moisture	Sample Weight (g)	Selenium	Mercury	Lead
White sucker (08)'	NIA	510.3	0.25	<0.10	<0.10
White. sucker (09)'	N/A	1204.8	0.29	<0.10	<0.10
White sucker (10)'	N/A	963.9	0.30	<0.10	co.10
White sucker (11)'	N/A	680.4	0.36	<0.10	<0.10
Fathead minnow (25)	77.	32.4	2.56	0.15	2.6
Fathead minnow (26)	76.9	69.3	3.08	0.219	0.669
Fathead minnow (58)	78.9	8.3	2.81	<0.0988	0.4
Fathead minnow (59)	76.3	37.7	2.91	0.231	2.26
Fathead minnow (111)	N/A	18.0	2.24	0.189	0.23
Fathead minnow (112)	N/A	16.0	1.7	<0.1	2.16
Fathead minnow (113)	N/A	4.0	1.16	0.342	0.342
Backswimmers (19)	82.6	3.0	1.4	0.405	0.93
Damselfly nymphs (20)	76.1	2.0	1.26	<0.133	0.997
Diving beetles (21)	67.9	40.1	0,879	< 0.0977	1.03
Water fleas (22)	87.8	3.5	1.87	<0.1799	50.2
Water fleas (23)	93.5	5.3	1.18	< 0.237	59.6
Crayfish (24)	76.3	34.2	1.82	<0.098	0.941
Backswimmers (51)	86.3	6.0	1.23	0.181	2.57
Damselfly nymphs (52)	61.3	3.1	0.714	< 0.2262	3.08
Damselfly nymphs (53)	84.4	3.9	1.72	<0.1193	0.47
Damselfly nymphs (54)	83.7	3.4	2.56	<0.1445	0.74
Snails (56)	N/A	4.8	1.04	< 0.1887	2.38
Crayfish (57)	65.2	366.3	0.818	< 0.0998	<0.1996
Dragonfly nymphs (105)	N/A	8.0	0.89	0.126	0.57
Crayfish (106)	61.8	86.	0.58	< 0.0988	0.92
Crayfish (107)	N/A	28.0	1.17	< 0.0992	0.55
Dragonfly nymphs (108)	N/A	4.0	0.72	0.136	1.23
Backswimmers (109)	N/A	9.5	0.94	0.349	1.29
Backswimmers (110)	N/A	9.5	0.87	0.192	0.2
Sediments (13)	37.7	428.4	< 0.2896	< 0.0965	15.8
Sediments (14)	64.3	278.5	0.419	< 0.0998	16.4
Sediments (15)	41.7	382.1	< 0.2994	<0.0998	17.7
Sediments (16)	58.6	337.9	0.547	co.0994	16.4
Sediments (17)	39.7	322.2	0.6	< 0.0984	9.15
Sediments (18)	37.9	402.3	< 0.297	< 0.099	16.5
Sediments (45)	37.4	365.8	< 0.2964	< 0.0988	15.

Appendix D.-Contaminant concentrations detected in sediment and biota samples collected at Las Vegas National Wildlife Refuge, June-September, 1991.

[Trace-element concentrations are in micrograms per gram. Abbreviations: *, Concentration is in wet weight units; ug/g, micrograms per gram; g, grams; < , less than detection limit; N/A, not ascertained]

			Trace-elements (ug/g, dry weight)		
Sample (Sample Number)▼	Percent Moisture	Sample Weight (g)	Selenium	Mercury	Lead
Bared grebe embryos (60)	76.9	64.6	2.65	0.357	<0.3914
Eared grebe embryos (61)	75.1	58.3	2.87	0.332	< 0.3984
Killdeer embryo (62)	71.4	11.3	1.44	0.275	< 0.3945
Barn swallow embryos (63)	82.6	6.8	5.07	0.242	< 0.3883
Juvenile mallard liver (64)	68.4	2.2	3.28	1.37	<0.2079
Juvenile mallard kidney (65)	76.6	0.7	3.96	0.673	< 1.8692
Juvenile mallard liver (66)	68.9	1.7	4.55	1.38	< 0.1961
Juvenile mallard kidney (67)	77.3	0.5	4.9	0.851	<2.1277
Juvenile mallard liver (68)	71.2	11.7	11.	0.676	<0.1965
Juvenile mallard kidney (69)	75.7	3.1	5.96	0.852	<0.4
Juvenile mallard. liver (70)	70.3	11.5	4.83	0.737	0.44
Juvenile mallard kidney (71)	75.8	5.8	5.97	0.729	< 0.3945
Juvenile eared grebe liver (125)	N/A	7.0	2.18	0.613	<0.1972
Juvenile eared grebe kidney (126)	N/A	3.5	3.05	0.742	0.77
Juvenile eared grebe liver (127)	NIA	8.0	2.55	0.528	0.26
Juvenile eared grebe kidney (128)	NIA	4.0	3.66	0.58	0.58
Juvenile eared grebe liver (129)	N/A	7.0	1.94	0.731	0.2
Juvenile eared grebe kidney (130)	NIA	4.0	2.85	0.729	0.51
Juvenile eared grebe liver (131)	NIA	10.0	2.39	0.651	< 0.4695
Juvenile eared grebe kidney (132)	N/A	5.0	3.36	0.752	0.62
Yellow-headed blackbird liver (27)	70.2	2.4	6.13	0.104	<0.1901
Yellow-headed blackbird kidney (28)	76.7	0.6	<7.8947	<2.6316	< 5.2632
Yellow-headed blackbird liver (29)	72.5	1.4	6.58	< 0.1247	< 0.2494
Yellow-headed blackbird kidney (30)	88.9	0.3	<15.	<5.	< 10.
Yellow-headed blackbird liver (32)	70.2	2.3	3.44	0.303	< 0.3984
Yellow-headed blackbird kidney (33)	74.3	0.6	5.3	<0.6024	<2.4096
Crappie (01)'	N/A	202.0	0.41	<0.10	co.10
Crappie (02)'	N/A	51.0	0.39	0.18	co.10
Crappie (03)'	N/A	51.9	0.36	0.20	<0.10
Crappie (04)'	N/A	60.6	0.42	0.22	co.10
Black bullhead (05)*	N/A	69.6	0.20	<0.10	<0.10
Black bullhead (06)*	N/A	46.8	0.23	0.22	<0.10
Black bullhead (07)*	N/A	255.1	0.17	<0.10	<0.10

Appendix C.-Identified species of birds sighted on two occasions during the Las Vegas National Wildlife Refuge 1991 investigation.

Bird Survey

Bird Species ▼	Bird Species ▼
American coot	Ferruginous hawk
Cinnamon teal	Kestrel
Bluewinged teal	Great blue heron
Readhead	Snowy egret
Ruddy duck	Blackcrowned night heron
Eared grebe	Double crested cormerant
Western grebe	Yellow-headed blackbird
Killdeer	Northern oriole
White-faced ibis	Eastern kingbird
Long-billed curlew	Western kingbird
Forster’s tern	Meadowlark
Say’s phoebe	American goldfinch
Rufous hummingbird	Lesser goldfinch
American robin	

Appendix B.-Analytical chemistry methodology employed to analyze samples for the 1991 Las Vegas NWR follow-up investigation.

1. **Homogenization A.** All samples were homogenized. Homogenization was preformed using a *Kitchen Aid* food processor. Portions were then freeze dried for determination of moisture content and subsequent acid digestion.

2. **Homogenization** B. Following freeze drying, samples were ground to approximately 100 mesh using a glass mortar and pestle.

3. **Digestion for Graphite Furnace Atomic Absorption (GFAA) Measurement.** Using a CEM microwave oven, 0.25 to 0.5 grams of freeze dried tissue were heated in a capped 120 mL *Teflon* vessel in the presence of 5 mL of *Baker Instra-Analyzed* nitric acid for three minutes at 120 watts. The residue was then diluted to 50 mL with laboratory pure water.

4. GFAA. GFAA measurements were made using a *Perkin-Elmer Zeeman* 3030 atomic absorption spectrophotometer with a *HGA-600* graphite furnace and an AS-60 autosampler.

5. **Digestion for Inductively Coupled Plasma Emission (ICP) Measurement.** Some 0.25 to 0.5 grams of sediment were placed in a 120 mL *Teflon* microwave vessel. One mL each of HCl, HF, and $HClO_4$, and 10 mL HNO, were added to the vessel. The vessel was then capped according to the manufacturer's instructions and was heated in a CEM microwave oven for two minutes at 120 watts, three minutes at 180 watts, and ten minutes at 600 watts. The resulting residue is diluted to 100 mL with 5 % HCl. This solution was then filtered through *Whatman 41* filter paper prior to ICP measurement. An HF resistance torch tip was used for these digests during the ICP measurement.

Appendix *A.--Continued.* Sample matrix, weight, location, and date of collection for all samples collected during the Las Vegas National Wildlife Refuge 1991 investigation.

Sample catalog

Sample (Sample Number)▼	Matrix (Composite amount)	Sample Weight (g)	Location	Date
Sediments (49)	Whole sediment	390.3	Middle Marshes	7/17/91
Sediments (50)	Whole sediment	442.3	Main Canal	7/18/91
sediments (99)	Whole sediment	304.8	Clodfelter Pond A	9/12/91
Sediment3 (100)	Whole sediment	375.0	Bentley Lake	9/11/91
Sediments (101)	Whole sediment	340.0	Main Canal	9/11/91
Sediments (102)	Whole sediment	354.4	Wallace Lake	9/11/91
Sediments (103)	whole sediient	375.6	Coyote Pond	9/12/91
Sediments (104)	Whole sediient	283.5	Middle Marshes	9/12/91

Appendix *A.-Continued.* Sample matrix, weight, location, and date of collection for all samples collected during the Las Vegas National Wildlife Refuge 1991 investigation.

Sample catalog

Sample (Sample Number)	Matrix (Composite amount)	Sample Weight (g)	Location	Date
White sucker (11)	Whole-fish	680.4	Bentley Lake	8/07/91
Fathead minnow (25)	Wholefish (> 13)	32.4	Bentley Lake	6/08/91
Fathead minnow (26)	Whole-fish (> 28)	69.3	Main canal	6/08/9 1
Fathead minnow (58)	Whole-fish (> 4)	8.3	Bentley Lake	7/15/91
Fathead minnow (59)	Whole-fish (> 15)	37.7	Main canal	7/15/91
Fathead minnow (111)	Whole-fish (> 7)	18.0	Bentley Lake	9/11/91
Fathead minnow (112)	Whole-fish (> 6)	16.0	Main Canal	9/11/91
Fathead minnow (113)	Whole-fish (> 2)	4.0	Wallace Lake	9/11/91
Backswimmers (19)	Wholebody (> 25)	3.0	Coyote Pond	6/17/91
Damselfly nymphs (20)	Whole-body (> 50)	2.0	Wallace Lake	6/17/91
Water bugs (21)	Whole-body (> 10)	40.1	Clodfelter Pond A	6/14/91
Water fleas (22)	Whole-body (> 1000)	3.5	Bentley Lake	6/14/91
Water fleas (23)	Whole-body (> 1000)	5.3	Middle Marshes	6/14/91
Crayfish (24)	Whole-body (9)	34.2	Main Canal	6/06/91
Backswimmers (51)	Whole-body (> 50)	6.0	Coyote Pond	7/17/91
Damselfly nymphs (52)	Whole-body (> 50)	3.1	Wallace Lake	7/17/91
Dragonfly nymphs (53)	Whole-body (> 25)	3.9	Clodfelter Pond A	7/18/91
Damselfly nymphs (54)	Wholebody (> 50)	3.4	Bentley Lake	7/17/91
Snails (56)	Whole-body (> 100)	4.8	Middle Marshes	7/17/91
Crayfish (57)	Whole-body (> 35)	366.3	Main Canal	7/18/91
Dragonfly nymphs (105)	Wholebody (> 33)	8.0	Clodfeker Pond A	9/12/91
Crayfish (106)	Wholebody (5)	86.0	Bentley Lake	9/11/91
Crayfish (107)	Wholebody (5)	28.0	Main Canal	9/11/91
Dragonfly nymphs (108)	Wholebody (25)	4.0	Wallace Lake	9/11/91
Backswimmers (109)	Wholebody (> 50)	9.5	Coyote Pond	9/12/91
Backswimmers (110)	Wholebody (> 50)	9.5	Middle Marshes	9/12/91
Sediments (13)	Whole sediment	428.4	Coyote Pond	6/13/91
Sediments (14)	Whole sediment	278.5	Wallace Lake	6/08/91
Sediments (15)	Whole sediment	382.1	Clodfelter Pond A	6/13/91
Sediments (16)	Whole sediment	337.9	Bentley Lake	6/18/91
Sediments (17)	Whole sediment	322.2	Middle Marshes	6/13/91
Sediments (18)	Whole sediment	402.3	Main Canal	6/08/9 1
Sediments (45)	Whole sediment	365.8	Coyote Pond	7/17/91
Sediments (46)	Whole sediment	348.0	Wallace Lake	7/17/91
Sediments (47)	Whole sediment	412.7	Clodfelter Pond A	7/18/91
Sediments (48)	Whole sediment	279.4	Bentley Lake	7/17/91

Appendix A.--Sample matrix, weight, location, and date of collection for all samples collected during the Las Vegas National Wildlife Refuge 1991 investigation.

Sample catalog

Sample (Sample Number)	Matrix (Composite amount)	Sample Weight (g)	Location	Date
Eared grcbe (60)	Embryo (3)	64.6	Wallace Lake	7/15/91
Eared grcbe (61)	Embryo (3)	58.3	Goose Island Lake	7/15/91
Kiidecr (62)	Embryo	11.3	Middle Marshes	6/18/91
Barn swallow (63)	Embryo (2)	6.8	Coyote Pond	6/18/91
Juvenile mallard (64)	Liver	2.2	Clodfelter Pond A	7/15/91
Juvenile mallard (65)	Kidney	0.7	Clodfelter Pond A	7/15/91
Juvenile mallard (66)	Liver	1.7	Clodfelter Pond A	7/15/91
Juvenile mallard (67)	Kidney	0.5	Clodfelter Pond A	7/15/91
Juvenile mallard (68)	Liver	11.7	Widgeon Pond	7/15/91
Juvenile mallard (69)	Kidney	3.1	Widgeon Pond	7/15/91
Juvenile mallard (70)	Liver	11.5	Melton Pond	7/11/91
Juvenile mallard (71)	Kidney	5.8	Melton Pond	7/11/91
Juvenile cared grcbe (125)	Liver	7.0	Goose Island Lake	8/07/91
Juvenile cared grcbe (126)	Kidney	3.5	Goose Island Lake	8/07/91
Juvenile eared grcbe (127)	Liver	8.0	Goose Island Lake	8/07/91
Juvenile eared grebe (128)	Kidney	4.0	Goose Island Lake	8/07/91
Juvenile cared grcbe (129)	Liver	7.0	Wallace Lake	8/07/91
Juvenile eared grebe (130)	Kidney	4.0	Wallace Lake	8/07/9 1
Juvenile eared grcbe (131)	Liver	10.0	Wallace Lake	8/07/91
Juvenile eared grcbe (132)	Kidney	5.0	Wallace Lake	8/07/91
Yellow-headed blackbird (27)	Liver	2.4	Coyote Pond	6/08/91
Yellow-headed blackbird (28)	Kidney	0.6	Coyote Pond	6/08/9 1
Yellow-headed blackbird (29)	Liver	1.4	Coyote Pond	6/08/91
Yellow-headed blackbird (30)	Kidney	0.3	Coyote Pond	6/08/91
Yellow-headed blackbird (32)	Liver	2.3	Melton Pond	7/11/91
Yellow-headed blackbird (33)	Kidney	0.6	Melton Pond	7/11/91
Crappie (01)	Fillet	202.0	Bentley Lake	8/07/91
Crappie (02)	Fillet	51.0	Bentley Lake	8/07/9 1
Crappie (03)	Fiiet	51.9	Bentley Lake	8/07/9 1
Crappie (04)	Fillet	60.6	Bentley Lake	8/07/9 1
Black bullhead (05)	Fillet	69.6	Bentley Lake	8/07/9 1
Black bullhead (06)	Wholefish	46.8	Bentley Lake	8/07/9 1
Black bullhead (07)	Whole-fish	255.1	Bentley Lake	8/07/9 1
White sucker (08)	Wholefish	510.3	Bentley Lake	8/07/9 1
White sucker (09)	Whole-fish	1204.8	Bentley Lake	8/07/91
White sucker (10)	Whole-fish	963.9	Bentley Lake	8/07/9 1

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protection criterion recommended by Eisler (1987). Mercury detected in avian livers indicate that migratory birds on Las Vegas NWR are not being exposed to harmful concentrations of mercury.

In summary, the results of this study indicate that selenium, lead, and mercury at Las Vegas NWR are not present in concentrations that likely cause adverse biological effects to fish or wildlife. Based upon these findings, further detailed investigation of these elements does not appear to be necessary. However, occasional monitoring of contaminant levels in sediment, water, and biota from Las Vegas NWR would be prudent,. particularly if there are any noticeable adverse changes to the surrounding ecosystem (e.g., population declines, high incidence of disease, neoplasms). Occasional contaminant monitoring of the refuge ecosystem may be accomplished through implementation of the National Biological Survey's new Biomonitoring of Environmental Status and Trends Program.

CONCLUSIONS AND RECOMMENDATIONS

In this investigation of selenium levels in sediment and biota from Las Vegas NWR, selenium concentrations did not exceed various protective criteria. Selenium concentrations in some samples of fathead minnows and aquatic invertebrates collected at the refuge approached the lower boundaries of some protective criteria. This could be a concern since these organisms are preyed upon by predatory birds. However, the selenium concentrations detected in these samples appeared within safe limits. Furthermore, selenium concentrations in livers from representative bird populations of adult mallards, juvenile yellow-headed blackbirds, and juvenile eared grebes indicated a low risk for adverse biological effects.

Results from the initial study in 1989 concluded that selenium concentrations were high in some fish samples, although only four samples were collected. The highest concentration of selenium in a fish sample collected in the initial study was 8.31 ug/g detected in minnows from Clodfelter Pond A. The results from this 1991 follow-up study indicate that selenium concentrations are not elevated in fish samples. A total of 18 fish samples were collected from three sites. The highest concentration of selenium was 3.08 ug/g detected in fathead minnows from the main canal. Considering the results from both investigations, it appears that selenium is not a problem at the refuge, although there may be a few isolated spots within the refuge where selenium concentrations exceed background levels.

Lead concentrations were also below a protective criteria threshold levels in all sediment and most biota samples collected. Although the highest concentrations of lead were consistently observed in samples from Bentley Lake, only a few aquatic invertebrate and fathead minnow samples contained concentrations of lead that could be considered elevated above normal background levels or capable of causing adverse effects to wildlife. Lead detected in avian livers indicate that migratory birds are not being exposed to harmful concentrations of lead.

Mercury was not detected in any of the 18 sediment samples collected. Aquatic invertebrate samples contained levels of mercury that could be considered background for areas uncontaminated by mercury. Fish samples collected from three sites also contained mercury below the predator protection criterion and is well within the standard analytical performance error of the Service's contract laboratories. Therefore, it would appear that migratory birds feeding on aquatic invertebrates and fish at Las Vegas NWR are unlikely to consume harmful levels of mercury.

The geometric mean concentration for mercury from the NCBP is 0.10 ug/g wwt, (0.33 ug/g dwt). All whole-fish samples collected from Bentley Lake were below the detection limit of 0.1 ug/g dwt (Table 5). Fillet samples of crappie and black bullhead ranged from <0.1 to 0.22 ug/g. Comparing these concentrations to the predator protection of 0.33 ug/g cited by Eisler (1987), it appears that fish at Bentley Lake do not contain harmful levels of mercury.

Table 'I.--Comparison of mercury concentrations detected in biota and sediments samples collected at Las Vegas National Wildlife Refuge on June 8-18, July 17-18, and September 11-12, 1991.

Mercury (ug/g, dry weight)

Location ▼	Sample	June 8	July 17	September 11
Coyote Pond	Sediments	<0.1	co.1	<0.1
Coyote Pond	Invertebrates	0.41	0.181	0.349
Wallace Lake	Sediments	<0.1	<0.1	<0.1
Wallace Lake	Invertebrates	<0.133	CO.23	0.136
Clodfelter Pond A	Sediments	<0.1	co.1	co.1
Clodfelter Pond A	Invertebrates	<0.1	<0.12	0.126
Middle Marshes	Sediments	<0.1	<0.1	co.1
Middle Marshes	Invertebrates	<0.24	<0.19	0.192
Bentley Lake	Sediments .	<0.1	co.1	co.1
Bentley Lake	Invertebrates	<0.18	<0.14	<0.1
Main Canal	Sediments	<0.1	<0.1	<0.1
Main Canal	Invertebrate8	<0.1	<0.1	<0.1

concentration detected in the test mallards which experienced abnormal behaviors and reduced productivity, Also, mercury concentrations detected in all aquatic invertebrates and fathead minnows were below the dietary level fed to mallards (0.5 ug/g), which caused abnormal behaviors and reduced productivity.

Mercury was detected in all four avian embryo samples collected at the refuge. Eisler (1987) has recommended that avian embryos should contain less than 0.9 ug/g wwt of mercury (3.0 ug/g dwt). The concentrations of mercury in avian embryo samples ranged from 0.242 to 0.357 ug/g dwt (Table 4). Based upon the criterion recommendation by Eisler, bird embryos collected from Las Vegas NWR do not appear to contain elevated concentrations of mercury.

As previously noted, Eisler (1987) recommended that, in order to protect avian predators, the concentration of mercury in food items should not exceed 0.33 ug/g. Mercury was detected in all seven fathead minnow samples. All but one fathead minnow sample was below the recommended 0.33 ug/g (Table 3). The sample of fathead minnows which exceeded Eisler's criterion contained a mercury concentration of 0.342 ug/g. This is only slightly above the recommended predator

Methylmercury causes damage to the central nervous system and is carcinogenic, mutagenic, and teratogenic to all animal species (Eisler 1987). Since mercury bioaccumulates and biomagnifies through the food chain, even low concentrations of mercury can still be dangerous to upper trophic level predators. The accumulation of mercury is rapid, but unlike selenium, depuration is slow (Stickel et al. 1977).

The geochemical baseline range for mercury concentrations in western soils is 0.0085 to 0.25 ug/g (Shacklette and Boemgen 1984). All 18 sediment samples collected at the refuge were less than the test instrument detection level of 0.01 ug/g (Table 7). Based on these findings, it appears that aquatic sediments at the refuge are generally uncontaminated by mercury. However, this determination does not necessarily rule out potential isolated spots that may have elevated levels of mercury, such as a point source attributable to an unknown input.

In a study conducted by Huckabee et al. (1979), aquatic insects (8 families) collected from mercury-contaminated areas contained 0.5 to 5.0 ug/g wwt of mercury and insects collected from uncontaminated areas contained 0.05 to 0.21 ug/g wwt. Also, Eisler (1987) recommended 0.33 ug/g as a predator protection level. Mercury was detected in six of 18 aquatic invertebrate samples. The mercury concentrations in the remaining 12 invertebrate samples were less than the detection levels (Table 7). Mercury was detected in all three aquatic invertebrate samples collected from Coyote Pond. The mean concentration of mercury in aquatic invertebrates collected at Coyote Pond was 0.312 $\pm$ 0.117 ug/g dwt (approximately 0.094 ug/g wwt). Although mercury concentrations in two aquatic invertebrate samples were above the predator protection level cited by Eisler, all of the detected mercury concentrations in aquatic invertebrates were below 0.5 ug/g wwt. Therefore, it would appear that aquatic invertebrates at Las Vegas NWR do not contain unusually elevated concentrations of mercury.

Heinz (1979) studied the effects of mercury on waterfowl via dietary exposure. Female mallards fed diets containing 0.5 ug/g of mercury throughout their lifetime resulted in liver mercury concentrations ranging from 3.0 to 5.4 ug/g dwt. These females laid a greater percentage of their eggs outside their nest boxes than did control mallards, and also laid fewer eggs and produced fewer ducklings. The mean concentration of mercury in all 11 bird liver samples collected at the refuge was 0.650 $\pm$ 0.431 ug/g (Table 4). This mean concentration is well below the liver mercury activity'. All but two aquatic invertebrates and small fish samples collected at Las Vegas NWR contained concentrations of lead below 25 ug/g. Water fleas collected from Middle Marshes and Bentley Lake contained 59.6 ug/g and 50.2 ug/g of lead, respectively. Based on the findings of Finley et al. (1976), the concentrations of lead in aquatic invertebrates and fathead minnows generally appear to be below the levels which would constitute a consumption-related hazard to migratory birds residing at Las Vegas NWR.

Eisler (1988) recommended that, for the protection of natural resources, the concentration of lead in the livers of waterfowl should not exceed 2 ug/g wwt (6.7 ug/g dwt); concentrations in excess of 8 ug/g wwt (26.7 ug/g dwt) can be considered evidence of poisoning. Additionally, Friend (1985) concludes that concentrations above 2 ug/g wwt (6.7 ug/g dwt) should be considered elevated. Lead in livers of all birds collected at the refuge ranged from < 0.19 to 0.44 ug/g dwt. The highest concentration was detected in the liver of an adult mallard collected at Melton Pond. Only three of 11 avian liver samples contained concentrations of lead above the detection level (Table 4). Therefore, it would appear that summer resident migratory birds at Las Vegas NWR are not accumulating harmful levels of lead.

MERCURY

Mercury is a highly toxic heavy metal with no known biological or nutritional function, and is not found as a natural element in the biological cycling of essential materials through aquatic ecosystems. The presence of mercury in any aquatic ecosystem usually indicates some degree of contamination. This contamination may be caused by natural circumstances, such as the presence of natural mercury deposits within a watershed being mobilized by weathering processes or volcanic activity, or by anthropogenic sources, such as the combustion of fossil fuels, agricultural fungicides, manufacturing thermometers, temperature controlled switches, ect., and pulp and paper manufacturing. The suspected mode of mercury flux into ecosystems with no apparent point source inputs is atmospheric deposition.

'Delta-aminolevulinic acid dehydrase (ALAD) is an enzyme that helps synthesize hemoglobin by catalyzing the formation of porphobilinogen, a precursor of heme. Lead exposure causes a dose-dependent decrease in ALAD activity in fish, birds, and mammals through direct inhibition of the enzyme. The measurement of ALAD activity is used as an indicator of lead exposure on an organism.

Table 6.--Comparison of lead concentrations detected in biota and sediments samples collected at Las Vegas National Wildlife Refuge on June 8-18, July 17-18, and September 11-12, 1991.

Lead (ug/g, dry weight)

Location ▼	Sample	June 8	July 17	September 11	Mean concentration
Coyote Pond	Sediments	15.8	15.0	10.0	13.6
Coyote Pond	Invertebrates	0.93	2.57	1.29	1.60
Wallace Lake	Sediments	16.4	16.1	13.6	15.4
Wallace Lake	Invertebrates	1.00	3.08	1.23	1.77
Clodfelter Pond A	Sediments	17.7	18.2	13.9	16.6
Clodfelter Pond A	Invertebrates	1.03	0.47	0.57	0.69
Middle Marshes	Sediments	9.15	17.0	15.6	13.9
Middle Marshes	Invertebrates	59.6	2.38	0.20	20.7
Bentley Lake	Sediments	16.4	25.5	11.3	17.7
Bentley Lake	Invertebrates	50.2	0.74	0.92	17.3
Main Canal	Sediments	16.5	16.7	14.4	15.9
Main Canal	Invertebrates	0.94	<0.2	0.55	0.53

increase with increasing age of the organism, and to localize in hard tissues such as bone and teeth (Eisler 1981, 1984). Based upon this information, it would seem that larger, older fish collected from Bentley Lake would contain relatively higher concentrations of lead. One possible explanation for this would be that the older fish samples and the fathead minnow samples were analyzed at different analytical laboratories. The concentrations of lead detected in the whole-fish and edible portion samples collected at Bentley Lake may have been unusually low based upon the fact that analytical laboratories commonly have a relatively high variation (often exceeding 40 percent) in their ability to detect analyte concentrations, due to different analytical techniques. However, the overall concentrations of lead in fish at Las Vegas NWR appear to be near background concentrations.

Finley et al. (1976) have studied the effects of lead on waterfowl via dietary exposure. Mallards fed diets containing 25 ug/g of lead for 12 consecutive weeks experienced only minor effects as a result. These effects included increased blood lead levels and a decrease in blood ALAD collected at the refuge were within the geochemical baseline range; three of these samples exceeded the geometric mean concentration (Table 6). The highest detected lead concentration in sediments was 25.5 ug/g from Bentley Lake. Long and Morgan (1990) suggested that the potential for biological effects of lead sorbed to sediments was highest in sediments where lead concentrations exceeded 110.0 ug/g and was lowest in sediments where lead concentrations were less than 35.0 ug/g. Based on these comparisons, it appears that sediments at the refuge do not have unusually elevated concentrations of lead.

Lead was detected in 17 of 18 aquatic invertebrate samples collected at the refuge (Table 6). Concentrations of lead in aquatic invertebrates were lowest at the Main Canal and Clodfelter Pond A. At these two sites, the concentrations of lead ranged from <0.2 to 1.03 ug/g. The highest concentrations were detected at Middle Marshes and Bentley Lake. At these two sites, the concentrations ranged from 0.20 to 59.6 ug/g. In crayfish samples collected from a river in Missouri, concentrations of lead were as high as 500 ug/g near a mine tailings pond (Gale et al. 1976). At 25 kilometers downstream, the concentration of lead dropped to 2.0 ug/g dwt. Based upon this comparison, it appears that some aquatic invertebrates may contain slightly elevated levels of lead.

Lead is highly toxic to aquatic organisms, especially fish (Rompala et al. 1984). The biological effects in sublethal concentrations of lead include delayed embryonic development, suppressed reproduction, inhibition of growth, increased mucous formation, neurological problems, enzyme inhibition, and kidney disfunction (Rompala et al. 1984; Leland and Kuwabara 1985). The geometric mean concentrations of lead in whole-fish from the 1980-1981 NCBP was 0.17 ug/g (Lowe et al. 1985). The mean concentration of lead in seven whole-fish composite samples of fathead minnow collected from three sites was 1.24 ± 1.05 ug/g. The highest concentration was detected from Bentley Lake (2.60 ug/g, see Table 3). The concentration of lead in all whole-fish and edible portion samples collected at Bentley Lake were below the detection limit of 0.1 ug/g (Table 5). Fathead minnows appear to contain slightly higher amounts of lead than the background level.

The concentrations of lead detected in the whole-fish and edible portion samples collected at Bentley Lake appeared to be unusually low compared to the concentrations detected in fathead minnows collected from the same site. Lead concentrations in fish and other vertebrates tend to

Table S-Concentrations of selenium, lead, and mercury detected in whole-fish and fillet samples of fish collected from Bentley Lake at the Las Vegas National Wildlife Refuge, 1991.

Selenium, Lead, and Mercury **(ug/g,** wet weight)

Sample (Matrix)	Selenium	**Lead**	Mercury
Crappie **(Fillet)**	0.41	**<0.10**	**<0.10**
Crappie **(Fillet)**	0.39	**<0.10**	0.18
Crappie (Fillet)	0.36	**<0.10**	0.20
Crappie **(Fillet)**	0.42	**<0.10**	0.22
Black bullhead (Fillet)	0.20	**<0.10**	**<0.10**
Black bullhead **(Fillet)**	0.23	**<0.10**	0.22
Black bullhead (Whole body)	0.17	**<0.10**	**<0.10**
White sucker (Whole body)	0.25	**<0.10**	**<0.10**
White sucker (Whole body)	0.29	co.10	**<0.10**
White sucker (Whole body)	0.30	**<0.10**	**<0.10**
White sucker (Whole body)	0.36	**<0.10**	**<0.10**

particles, after being discharged through automobile exhausts. Once on the road and surrounding areas, rainwater dissolves the lead and from there, it can drain into wildlife habitat where it becomes a potential contaminant (Eisler 1988).

Hunting areas also have a high potential for lead poisoning in wildlife when lead is introduced from spent lead shot (Eisler 1988). In North America alone, approximately 3,000 tons of lead shot are expended annually into lakes, marshes, and estuaries by several million waterfowl hunters **(USFWS** 1986b). Ingestion of spent lead shot and subsequent poisoning accounts for the estimated death of two percent of the continental migratory waterfowl population each year. Spent pellets ingested by waterfowl and other birds are retained in the gizzard where they are ground up into microscopic particles capable of passing through the intestinal wall and being transported by the blood. Lead toxicosis and death may result from the ingestion of as few as two spent pellets (Street 1983).

The geochemical baseline range for lead concentrations in western soils is 5.2 to 55.0 **ug/g** and the geometric mean is 17.0 **ug/g** (Shacklette and Boemgen 1984). All 18 sediment samples

Table 4.--Concentrations of selenium, lead, and mercury detected in **avian** tissues at Las Vegas National **Wildlife** Refuge, **199** 1.

Selenium, Lead, and Mercury (ug/g, dry **weight)**

Location ▾	Sample (Matrix-composite)	Selenium	Lead	Mercury
Coyote Pond	Barn Swallow (Embryo-2)	5.07	<0.39	0.242
Wallace Lake	Bared grebe (Embryo-3)	2.65	<0.39	0.357
Goose Island	Bared grebe (Embryo-3)	2.87	< 0.40	0.332
Middle Marshes	Killdeer (Embryo)	1.44	<0.39	0.275
Coyote Pond	Juvenile yellow-headed blackbird (Liver)	6.13	<0.19	0.10
Coyote Pond	Juvenile yellow-headed blackbird (Liver)	6.58	<0.25	<0.12
Melton Pond	Juvenile yellow-headed blackbird (Liver)	3.44	<0.40	0.303
Clodfelter Pond A	Mallard (Liver)	3.28	co.21	1.37
Clodfelter Pond A	Mallard (Liver)	4.55	< 0.20	1.38
Widgeon Pond	Mallard (Liver)	11.0	co.20	0.676
Melton Pond	Mallard (Liver)	4.83	0.44	0.737
Wallace Lake	Juvenile eared grebe (Liver)	1.94	0.20	0.731
Wallace Lake	Juvenile eared grebe (Liver)	2.39	<0.47	0.651
Goose Island Lake	Juvenile eared grebe (Liver)	2.18	< 0.20	0.613
Goose Island Lake	Juvenile eared grebe (Liver)	2.55	0.26	0.528

fish. Mean concentrations were calculated from the results of 321 composite samples of whole adult fish collected at 112 stations in major rivers throughout the United States (Schmitt and Brumbaugh 1990). The geometric mean whole-fish selenium concentrations for white sucker collected from Las Vegas NWR was 0.30 ug/g (Table 5). Selenium concentrations above 2.0 ug/g in whole-fish samples are rarely related to adverse effects on fish species, but are elevated above typical background levels (Gober 1993). All whole-fish samples collected from Las Vegas NWR were below 2.0 ug/g.

LEAD

Lead is a ubiquitous trace metal characteristically found in rocks, soils, water, plants, animals, and air. Lead has no known beneficial nutritional characteristics to living organisms, and is toxic in most of its chemical forms (Jenkins 1981). Lead concentrations have been found to be highest near areas of lead mining, refining, high motor vehicular traffic, urban zones, and hunting areas (Eisler 1988). Near areas of motor vehicular traffic, lead adsorbs to pavement, rock, and soil mosquitofish was 170 ug/g (range from 115 to 283 ug/g Se) (Ohlendorf et al. 1986). Based upon this comparison, it would appear that fathead minnows collected from Las Vegas NWR do not contain concentrations of selenium approximating normal background levels.

Skorupa et al. (in review) developed systematic guidelines for interpreting selenium concentrations in livers and eggs of breeding waterbirds. The authors concluded that population mean selenium concentrations in avian livers of breeding birds below 10 ug/g indicated a low risk for selenium-related embryonic deformity, while concentrations in livers in excess of 30 ug/g selenium indicated a high risk for embryonic deformities. Population mean liver selenium concentrations for breeding birds between 10 and 30 ug/g were identified as being in a region of uncertainty of biological risk, and would require further direct studies of avian reproductive performance. The highest individual selenium concentrations in avian livers collected from Las Vegas NWR were detected in mallard (11 .O ug/g), and juvenile yellow-headed blackbirds (6.58 and 6.13 ug/g, see Table 4). Geometric mean (population mean) liver selenium concentrations were calculated for mallard (5.31 ug/g), juvenile yellow-headed blackbirds (5.18 ug/g), and juvenile eared grebes (2.25 ug/g) collected at Las Vegas NWR. Based on interpretive guidelines developed by Skorupa et al. (in review), avian liver selenium concentrations observed in bird samples from Las Vegas NWR indicate a low risk of selenium-related adverse biological effects.

Interpretive risk thresholds from avian egg residue data were developed by Skorupa et al. (in review). The authors concluded that individual eggs containing less than 10 ug/g would be at low risk of having a deformed embryo and that individual eggs containing greater than 50 ug/g would be at high risk of having a deformed embryo. Individual selenium egg residues between 10 and 50 ug/g would be in a region of uncertainty for biological risk, and would require further direct studies of avian reproductive performance. Embryos were collected from eared grebes, killdeer, and barn swallows at Las Vegas NWR. All eggs collected showed no embryonic development and may have been abandoned. Selenium concentrations for all avian egg samples were within the range of low biological risk (C 10 ug/g, see Table 4).

The geometric mean concentrations of selenium in whole-fish from the 1980-1981 National Contaminant Biomonitoring Program (NCBP) was 0.47 ug/g (Lowe et al. 1985). The NCBP is a nationwide network of stations designed to monitor the concentrations of contaminants in freshwater ug/g dwt (between 4 and 7 ug/g wwt with 10% moisture content; Smith and Heinz 1990) selenium as selenomethionine. Food organisms of migratory birds include aquatic invertebrates, fish, and vegetation. Most of the lakes and ponds at the refuge produced an abundance of aquatic invertebrates, and small fish were also present at some sites. The concentrations of selenium detected in suitable avian food organisms ranged between 0.58 and 3.08 ug/g. Each of these samples were below the recommended dietary range for selenium in avian food organisms (Table 2 and 3). Based upon this comparison, it appears that selenium in organisms within the lower trophic levels of the aquatic ecological food chain at Las Vegas NWR is unlikely to pose health or reproductive risks to migratory birds.

Fish can take up selenium from contaminated food items in addition to intake from sediments and water (Lemly and Smith 1987; Ohlendorf 1989). The mean concentration of selenium in seven composite samples of fathead minnows from three sites was 2.35 $\pm$0.70 ug/g (Table 3). These three sites were Bentley Lake, Wallace Lake, and the Main Canal. Of the seven samples, the highest concentration was detected from the Main Canal (3.08 ug/g). In an irrigation drainwater study in the San Joaquin Valley of California, the geometric mean concentration of selenium in mosquitofish collected from the Volta Wildlife Area (Volta) control site was 1.29 ug/g. Volta does not receive drainwater and is considered to be a selenium-clean area. Conversely, at the selenium-contaminated irrigation drainwater ponds at Kesterson NWR, the geometric mean concentration of selenium in

Table 3.--Concentrations of selenium, lead, and mercury detected in fathead minnow composite samples collected from the Las Vegas National Wildlife Refuge, 1991.

Selenium, Lead, and Mercury (ug/g, dry weight)

Sample (Location)	Selenium	Lead	Mercury
Fathead minnows (Bentley Lake)	2.56	2.6	0.15
Fathead minnows (Bentley Lake)	2.81	0.4	co.1
Fathead minnows (Bentley Lake)	2.24	0.23	0.189
Fathead minnows (Main Canal)	3.08	0.669	0.219
Fathead minnows (Main Canal)	2.91	2.26	0.231
Fathead minnows (Main Canal)	1.7	2.16	<0.1
Fathead minnows (Wallace Lake)	1.16	0.342	0.342

Table 2.--Comparison of selenium concentrations detected in biota and sediments samples collected at Las Vegas National Wildlife Refuge on June 8-18, July 17-18, and September 11-12, 1991.

		Selenium (ug/g, dry weight)			
Location ▼	Sample	June 8	July 17	September 11	Mean concentration
Coyote Pond	Sediments	co.3	<0.3	<0.3	***
Coyote Pond	Invertebrate4	1.40	1.23	0.94	1.19
Wallace Lake	Sediments	0.42	<0.3	<0.3	***
Wallace Lake	Invertebrates	1.26	0.714	0.72	1.00
Clodfelter Pond A	Sediments	co.3	<0.3	0.54	***
Clodfelter Pond A	Invertebrates	0.88	1.72	0.89	1.11
Middle Marshes	Sediments	0.60	<0.3	0.33	0.36
Middle Marshes	Invertebrates	1.18	1.04	0.87	1.03
Bentley Lake	Sediments	0.55	0.68	0.39	0.55
Bentley Lake	Invertebrates-	1.87	2.56	0.58	1.67
Main Canal	Sediments	<0.3	<0.3	0.38	***
Main Canal	Invertebrates	1.82	0.818	1.17	1.27

[***, sample type not collected]

Benthic and other aquatic organisms usually receive most of their selenium either by direct contact with seleniferous sediments, or intake of selenium dissolved in water (Lemly and Smith 1987). Under baseline conditions (i.e., those conditions not greatly influenced by human-induced mobilization of selenium), environmental concentrations of selenium rarely exceed 5 ppm in aquatic invertebrates (Hothem and Ohlendorf 1989). Selenium was detected in all 18 aquatic invertebrate samples collected at the refuge (Table 2). Selenium concentrations ranged from 0.58 to 2.56 ug/g in aquatic invertebrates. The mean concentration of selenium in aquatic invertebrates was highest at Bentley Lake (1.67 $\pm$ 1.01 ug/g). In aquatic ecosystems that have normal levels of selenium, waterbirds that feed on aquatic invertebrates are usually exposed to an average of < 1.2 ug/g dietary selenium (CH2M Hill et al. 1993). . The results of this investigation indicate that the concentrations of selenium in aquatic organisms collected from Las Vegas NWR are not elevated above normal background levels.

Based on the studies by Heinz et al. (1989) and Smith and Heinz (1990), the incidence of reproductive impairment significantly increases when avian food sources contain between 4.4 and 7.8

Evaluations of analytical data obtained in this study were based upon comparisons with published scientific findings. Selenium, lead, and mercury values throughout this report are reported in dry weight units unless noted otherwise. This is due to the fact that the analytical laboratory could not provide the moisture content for some samples. When necessary, wet weight values from published scientific findings (that did not report moisture content values) were converted to dry weight values by assuming a 70% moisture content.

SELENIUM

Selenium is a semimetallic trace element that occurs in both organic and inorganic forms. Selenium is an essential nutrient in trace quantities, but quickly becomes toxic when excessive concentrations are present. In the environment, most selenium originates in seleniferous rocks and soils and is usually introduced into an aquatic system by groundwater processes or by uptake from plant roots (Eisler 1985; Lemly and Smith 1987; Ohlendorf 1989). Sediments and soils may only be a temporary repository for selenium, since biological, chemical, and physical processes mobilize selenium both into and out of sediments (Lemly and Smith 1987). Once into plant tissue or dissolved in water, selenium can bioaccumulate directly into biota. When selenium becomes available to fish, birds, and mammals, it can bioconcentrate in tissues to several orders of magnitude higher than that of the food source. For example, fish that have eaten selenium contaminated plankton or benthic fauna may contain 4 times the selenium concentration of their diet, which in turn could contain 500 times the selenium concentration of the water. Even though concentrations of selenium in water may be low, predatory fish, birds, and mammals can still receive toxic levels of selenium from their diet (Lemly and Smith 1987). Upon exposure, selenium is quickly accumulated into body tissues (7.8 days in liver), and is also rapidly depurated (half-time of 18.7 days) once the dietary exposure has ceased (Heinz et al. 1990).

The geochemical baseline range for selenium concentrations in western soils is 0.039 to 1.4 ug/g and the geometric mean is 0.23 (Shacklette and Boemgen 1984). Concentrations of selenium in all 18 sediment samples were within the baseline range (Table 2). The highest selenium concentration detected was 0.68 ug/g from Bentley Lake. Sediments from Bentley Lake also had the highest mean concentration of selenium for the three samples collected (0.54 $\pm$ 0.15 ug/g). At the other five sites, at least one of the three sediment sample collected at each respective site contained less than the detection level for selenium (C 0.3 ug/g).

embryonic material was removed from the shell for analysis. One killdeer egg was taken for analysis. At each site, one egg from three different eared grebe nests was composited and submitted for analysis. All bird samples were stored in either ***Whirl-packs*** or chemically cleaned glass containers. These samples were stored on ice in the field and later frozen.

Aquatic invertebrate samples consisted of taxa-specific composites of damselfly nymphs (Order: *Odonata*), dragonfly nymphs (*Odonata*), predatory diving beetles (*Diptera*), water fleas (*Cladocerca*), crayfish ***(Decopodu),*** backswimmers (*Hemiptera*), and snails (Class: *Gastropoda*). Aquatic invertebrates were collected at each site according to availability, using sieves, seines, and plankton nets. When possible, the same invertebrate species were recollected at each location during subsequent sampling efforts. All aquatic invertebrate samples were stored in *Whirl-paks*. ***These*** samples were stored on ice in the field and later frozen.

Sediment and biota samples were packed in dry ice and shipped to Research Triangle Institute (RTI) in Research Triangle Park, North Carolina. Each sample was homogenized, freeze dried, and digested with nitric acid. All samples were analyzed for selenium, mercury, and lead using graphite furnace atomic absorption measurements. For a general description of the methods employed to analyze samples at RTI, see Appendix B. Whole-fish and fillet samples collected at Bentley Lake were analyzed at the New Mexico Department of Health's Scientific Laboratory Division in Albuquerque, New Mexico.

RESULTS AND DISCUSSION

Reproductive success was seemingly poor for mallards and shorebird species that attempted to nest at Las Vegas NWR during the 1991 breeding season. Only one mallard and two killdeer nests were found on the refuge. Within a few days of discovery, each nest was destroyed by predators. Several eared grebe broods were observed in late summer. More than 100 eared grebe nests were located in Wallace Lake and Goose Island Lake. Reproductive success was also good for yellow-headed blackbirds. Approximately 10 nests were located during the study period, and most of these produced viable young. Juveniles from these nests were collected for analysis. A list of the species of birds observed at the refuge during the study period is contained in Appendix C.

Table l.--Name and description of site locations where samples were collected for the Las Vegas National Wildlife Refuge 1991 follow-up investigation.

sii **Location Description**

Site name ▼	Site description ▼
Bentley Lake	Large deepwater habitat lake, approximately 19.4 surface hectares.
Wallace Lake	**Large** deepwater habitat lake, approximately 56.8 surface hectares.
Coyote Pond	Small shallow water habitat pond, maximum depth approximately 2 meters, 6.4 surface hectares.
Middle Marshes	Small shallow water habitat pond.
Clodfelter Pond A	Small shallow water habitat pond with islands, approximately < 6.0 surface hectares.
Main canal	Main irrigation canal that diitriiutes water to other water bodies on the refuge. Maximum estimated width = 2.5 meters.
Widgeon Pond	Small shallow water habitat pond, approximately 1.1 surface hectares Only migratory birds **collected.**
Melton Pond	Large deepwater habitat lake, approximately 9.1 surface hectares. Only migratory birds collected.
Goose Island Lake	Large deepwater habitat lake with islands, approximately 47.1 surface hectares. Only migratory birds collected.

samples. Black bullheads and white suckers collected from Bentley Lake were analyzed as individual whole-fish samples. White crappie fillets were removed from the left side of the fish and analyzed individually. All fish samples were stored in either ***Whirl-paks*** or ***Ziploc*** freezer bags. These samples were stored on ice in the field and later frozen.

Tissue samples collected **from** birds consisted of individual livers and kidneys from adult yellow-headed blackbirds **(*Xanthocephalus xanthocephalus*),** juvenile mallards ***(Anus platyrhynchos)*** and ***eared*** grebes ***(Podiceps nigricollis*).** **Killdeer (*Charadrius vociferus*),** ***eared*** grebe, and barn swallow **(*Hirundo rustica*)** embryos were also collected. Adult and juvenile birds were shot with steel shot or hand captured, dissected, and their livers and kidneys removed. The liver and kidney from each specimen were analyzed individually. Bird eggs were hand gathered from nests, scored, and the from an existing water body into a larger pond. Bentley Lake, Melton Pond, Wallace Lake, and Goose Island Lake are all relatively large lakes, classified as lacustrine deepwater habitats (water depths greater than 2 meters). Widgeon Pond, Coyote Pond, Clodfelter ponds, and Middle Marshes are classified as palustrine habitats (area is less than 8 hectares and water depths less than 2 meters). All lakes and ponds on the refuge primarily receive water from Storrie Reservoir, eight miles north of the refuge. McAllister Lake is not part of Las Vegas NWR, and is maintained by the New Mexico Department of Game and Fish as a fishing area. McAllister Lake receives seepage water from Middle Marshes. Widgeon Pond receives some water from Bentley Lake via an underground pipe. Clodfelter ponds receive water via a lateral canal. For a list of all sites where samples were collected during this investigation, see Table 1.

MATERIALS AND METHODS

Sediment, aquatic invertebrates, and fish samples were collected at each of the six sites on June 8, July 17, and September 11, 1991. Fish from Bentley Lake were collected on August 7, 1991. Migratory bird samples were collected throughout the study period when they were available.

A stainless steel *Ekman* dredge was used to collect sediment from the approximate center at each of the deepwater habitats sampled. Each sediment sample consisted of a composite of 2 to 3 dredge collections. A *Wildco* stainless steel hand corer was used to collect sediments at each of the shallow ponds and the main canal. Each sediment sample consisted of a composite of several cores. Since contaminants that are sorbed to sediment fines of the uppermost layer of sediment are more bioavailable and more easily accessible than those in deeper layers, only the top few centimeters of sediment were collected for analysis. All sediment samples were filtered through a 2-millimeter pore diameter sieve to remove pebbles and large pieces of vegetation. Then, the sieved sediment fines were placed into chemically cleaned glass containers and were stored on ice in the field and later frozen.

Fish samples consisted of whole-fish composites of fathead minnows (*Pimephales promelas*), individual fillet samples of white crappie (*Poxomis annularis*), and individual whole-fish samples of black bullhead (*Ameiurus melas*) and white sucker (*Catostomus commersoni*). Fish were collected using seines and gill nets. Individual fathead minnows were combined into whole-fish composite

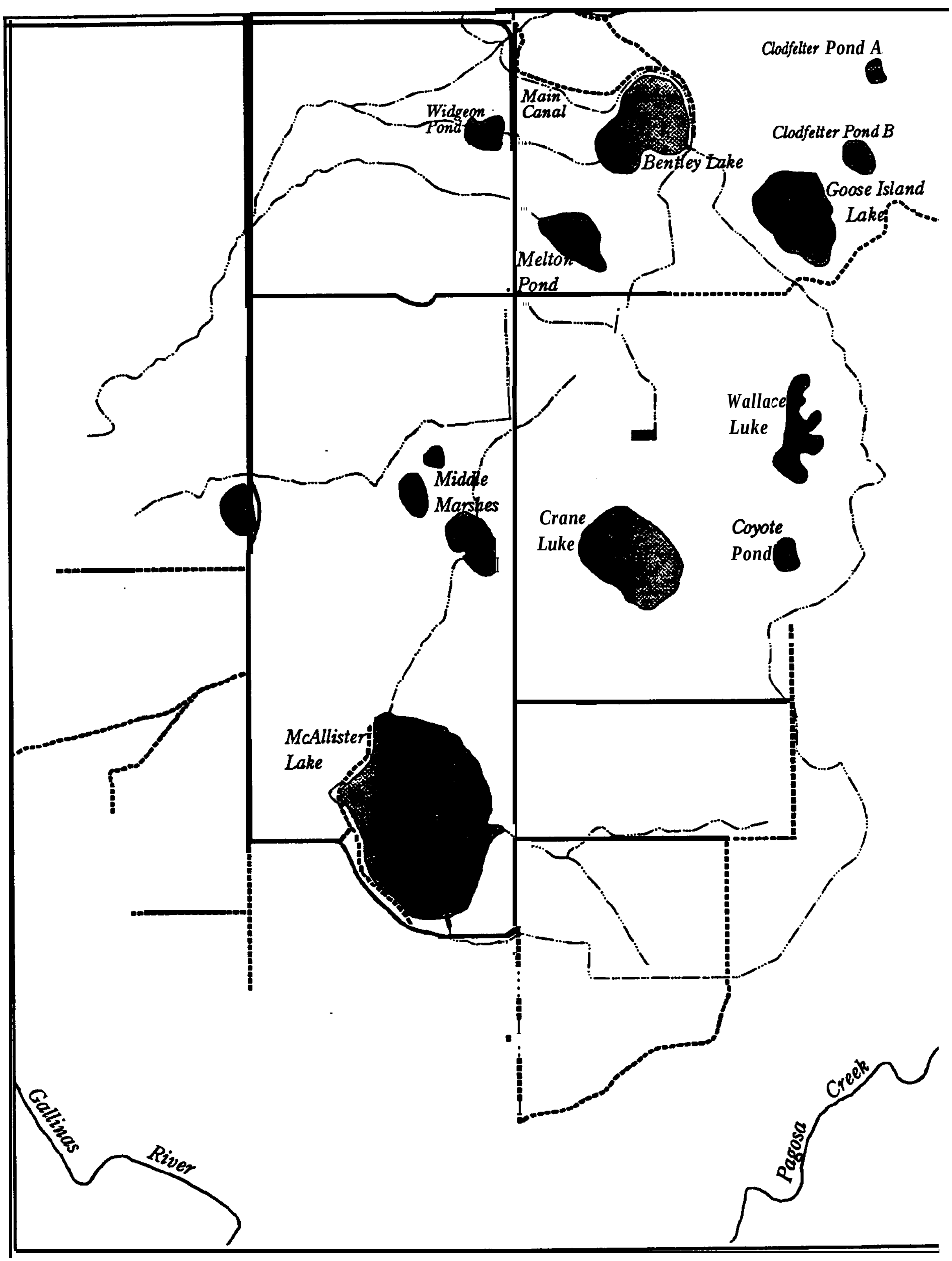

Figure l.--Location of Sample Collection Sites at Las Vegas NWR.

STUDY AREA

The Las Vegas NWR was established in 1966 by the Migratory Bird Conservation Commission under authority of the Migratory Bird Conservation Act. The refuge is located in San Miguel County in northern New Mexico, approximately 70 miles east of Santa Fe, New Mexico, and approximately six miles east of the City of Las Vegas (Figure 1). The refuge lies within the Pecos River basin, and ponds within the refuge receive water from Storrie Reservoir via an earthen irrigation canal. The average annual rainfall at Las Vegas NWR is 16.28 inches, and has a total annual evaporation of 53 inches. In 1991, the refuge received 14.58 inches of rainfall. The elevation of the refuge ranges from 6140 to 6520 feet above mean sea level.

A portion of the refuge is dedicated to growing agricultural crops such as barley, wheat, corn, winter peas, and other small grains for wildlife feed. The crops grown on the refuge are strictly for wildlife use and are not harvested for other uses. Cattle and pronghom grazing also takes place on the refuge. The refuge offers a short goose and dove hunting season, and since 1984 has required that hunters use steel rather than lead shot, since spent lead pellets can be toxic to migratory birds that ingest them.

Six sites were selected to sample sediment, aquatic invertebrates, and fish based upon the following criteria: (1) contamination problems potentially linked to irrigation water and water management practices; (2) area importance in terms of human and land management activities; (3) area importance in terms of migratory bird use. The selected sites included Bentley Lake, Middle Marshes, Wallace Lake, Clodfelter Pond A, Coyote Pond, and the main irrigation canal (main canal) that delivers water to several fields and ponds throughout the refuge. At each of these sites, sediment and biota samples were collected on three separate occasions. Collections of game fish and bullheads were also made at Bentley Lake. Additional avian samples were collected at Widgeon Pond, Melton Pond, and Goose Island Lake.

The refuge boundary encompasses approximately 3469 hectares (ha), and contains 41 lakes and ponds totaling 217.6 surface hectares. The size of the lakes and ponds range from 56.8 surface hectares at Wallace Lake to 0.04 surface hectares at the smallest pond. Several of the ponds and lakes on the refuge were either created by man when the refuge was established, or have been modified

INTRODUCTION

The U.S. Fish and Wildlife Service (Service) is concerned with organic and inorganic contaminants that may be introduced into national wildlife refuge ecosystems through irrigation drainwater. The Service has documented significant adverse biological effects associated with drainwater contamination in the western United States (Stephens et al. 1988; See et al. 1992; USFWS 1986a). Las Vegas NWR, located in northern New Mexico, was identified as a site that could potentially be receiving contaminants in irrigation water and from associated water management practices. As a result, sediment and biota samples were collected from Las Vegas NWR in 1989 and chemically analyzed for potentially toxic trace elements, residues of organochlorine pesticide compounds, and polychlorinated biphenyls (PCBs). The results of this preliminary study indicated that migratory birds contained elevated concentrations of selenium and mercury (Bristol and Shomo 1993). Composite avian liver/kidney samples had a mean selenium concentration of 9.39 ug/g dwt. The highest concentration of selenium observed in migratory birds collected from the refuge was from an adult mallard (21.00 ug/g dwt). The mean concentration of mercury detected in all migratory bird samples collected was 1.35 ug/g dwt, with the highest concentration detected in a teal (*Anas sp.*) liver/kidney composite sample (2.90 ug/g dwt). Since both selenium and mercury bioaccumulate through the food chain, it was theorized that migratory birds might be accumulating harmful levels of these elements from food sources at the refuge. Low concentrations of selenium and mercury in water and primary trophic level organisms can bioaccumulate in tissues of primary trophic level organisms which in turn, are consumed by higher trophic level organisms. Thus, these potentially toxic elements can bioconcentrate in the tissues of higher level consumers and may cause adverse effects.

In 1991, the Service conducted a follow-up investigation *to more* fully determine the extent of selenium and mercury contamination on the refuge and to identify possible paths of bioaccumulation. During the follow-up investigation, sediment and biota samples were collected at six sites on the refuge on three separate occasions between June 8 and September 12, 1991. Avian adults, juveniles, and eggs were collected when available. Tissue and sediment samples collected for this study were also analyzed for lead because detection limits in the initial 1989 study were not low enough to evaluate potential risks that this element might pose to fish and wildlife at the refuge.

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APPENDICES

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EXECUTIVE S -Y

In 1989, the U.S. Fish and Wildlife Service (Service) conducted an environmental contaminant survey of Las Vegas National Wildlife Refuge (Las Vegas NWR). This study revealed elevated levels of selenium and mercury in fish and avian samples collected from the refuge. A follow-up investigation was conducted during the summer of 1991 to determine: (1) the nature and extent of selenium, lead, and mercury contamination at Las Vegas NWR, and (2) how such contamination might affect fish and wildlife resources.

Eighteen sediment and 62 biological samples were collected at nine sites on the refuge. Each sample was assayed for selenium, lead, and mercury. Samples were assayed for lead because the detection limits in the 1989 study were not low enough to evaluate potential risks that this element might pose to fish and wildlife.

All bird tissue samples collected in the 1991 study contained acceptable levels of selenium. Out of a total of 26 bird tissue samples analyzed, only one bird tissue sample had a selenium concentration greater than 10 **ug/g.** Selenium concentrations in avian livers collected from birds residing at Las Vegas NWR indicated a low risk for adverse biological effects.

Lead concentrations were below a level for concern in all sediment and most biota samples collected. Some aquatic invertebrate and fathead minnow samples contained concentrations of lead that could be considered elevated above background and possibly capable of causing adverse effects to wildlife.

The concentration of mercury appeared to be below levels of concern in all media sampled at Las Vegas NWR. Mercury was not detected in 12 of the 18 aquatic invertebrate samples, and was not detected in any of the sediment samples collected.

ABBREVIATIONS AND CONVERSION FACTORS

Abbreviations

parts per million	**ppm**
parts per billion	**ppb**
micrograms per gram	**ug/g**
micrograms per day	ugldday
micrograms per liter	**ug/L**
dry weight	dwt
wet weight	**wwt**

Conversions

micrograms per gram	**ppm**
micrograms per liter	**ppb**

Dry weight = Wet weight.0 - (Moisture % / 100)